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SPECIFICATION OF INVENTION
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(54) A CENTERING MACHINE

Abstract

(57) The invention relates to machining metal objects, particularly to centering machines for large shafts in flexible automatic systems of production as well as for individual production in heavy engineering industry.

The objective of the invention is to widen machine's capabilities. A centering machine comprises adjustable supports arranged on a base and centering heads with work tools configured to be positioned, an additional sliding carriage with a sensitive element touching the surface of a blank, and a system of microprocessor control.

The system of microprocessor control comprises a microprocessor configured for selecting optimal technological and economic process of machining and correcting by shaping. The sensitive element arranged at a rotating part of the carriage moving along the base is a displacement sensor with a contact element connected to the sensor shaft with a lever. The sensitive element registering geometrical parameters of the blank surface at the same time has a function of visual indication of some special points of the blank surface, for example the lowest and the highest points. For these purposes it is capable of continuous motion and halts at the special points calculated by the microprocessor and initiated by the contact element of the sensor. The lever of the contact element is connected to a drive, for example

an electromagnet for moving the contact element to the blank surface or removing in to a fixed stop. 3 dependent claims, 7 drawings.

Description of the invention

The invention relates to machining metal objects, particularly to centering machines for large forged shafts in flexible automatic systems of production as well as for individual production in heavy engineering industry.

The objective of the invention is to widen machine capabilities, to provide automation of visual indication of blank defect points and to decrease machining working time. Technological process of machining can be divided into a few levels. The first level is the lowest one identical to a process using known machines. In this variant a blank can be centered after being arranged on adjusted supports; in such case centering is defined by the geometry of then shaft ends on the supports not taking into account the geometry of the other parts of the surface. The second level is higher, it includes possibility of orientation of blank center axes in space relative to its surface taking into account the geometry of the other parts of the surface. It is achieved due space orientation of the centering heads and additional carriage having the sensitive element arranged on the base interconnected in the system of microprocessor control configured for selecting an optimal process of further machining, and also due to the sensitive element placed on the rotating part of the carriage moving along the base and comprising a motion transducer with a contact element connected by a lever with its axis and detecting geometrical parameters of the blank.

The features indicated above provide for real blank surface geometry data accumulating in the microprocessor memory and their processing by the microprocessor calculating according to a predetermined program such space position of the blank center axis (and values of centering heads positioning corresponding to this position) that complies with possible uniform distribution of allowance for further machining.

With the help of the microprocessor control system required positioning and centering are achieved. Technological machine's capabilities of the second level are realized automatically when the blank has no defects (hogging, depression) that should be repaired by leveling or weld deposition and when microprocessor technical and economical calculations show that use of above repairs is not justified economically. Processing at the second level decreases labour-output ratio of further machining due to optimal distribution

of the allowance and cost of repairs.

The third level comprises developing an automatic machining program by the microprocessor for the blank on the basis of its real surface geometry saved in memory thereby decreasing labour-output ratio due to cutting the time of "machining air" and completely automatic further machining. The third level is used automatically after the second level in cases when further machining is on a numerical control machine.

The fourth level includes preparing journals for support holders to place the blank on the machine using adjustable movable supports and continuously moving and rotating part of the carriage.

The fifth level includes visual indication of special (the highest and lowest) points of the blank surface. It is provided by the motion transducer which in addition to the features mentioned above of being provided with the contact element connected by the lever with the shaft also has a function of visual indication of the special points stopping at special points calculated by the microprocessor; and the contact element lever is connected to the drive through an electromagnet. The fifth level is applied in cases when obtaining a proper finished article is not possible without weld deposition and/or leveling and also when it is technologically and economically advisable to repair the blank before machining (for even distribution of allowance and decreasing machining time).

In such case the features preceding the fifth level are realized after blank repair. The repair, for example, by weld depositing can be done without removing the blank from the machine or at some other place.

Fig. 1 represent the diagram of the claimed machine;

Fig. 2 shows assembly 1 in Fig. 1 in connection with other elements of the machine of Fig. 1;

Fig. 3 shows cross section along line A-A of Fir. 1;

Fig. 4 is view B in Fig. 3;

Fig. 5 shows cross section along line B-B of Fir. 1;

Fig. 6 represents the diagram of allowance distribution of a blank requiring to be repaired by weld depositing;

Fig. 7 represents the diagram of allowance distribution of a blank with hogging requiring to be repaired by leveling;

The machine comprises a machine stand 1 with central heads 2 and work tools 3. Central heads 2 can move along the stand for adjusting the machine for processing blanks of different sizes. They are movable along two axes in the plane perpendicular to stand 1. Work tools 3 can be quickly advanced and fed for cutting.

Adjustable supports 4 that can be moved along for mounting a blank are placed on the stand. Mounting units 6 serve for fixing the blank.

Carriage 7 movable in longitudinal direction with rotatable part 8 of a ring shape located in an inner cavity of the carriage body is arranged on the stand. Part 8 comprises a sensor 9 of angular motion (further sensor 9 for short). Ring 8 rotation and carriage 7 linear motion are interconnected kinematically (not shown in the figures) and can be controlled. There is a row of evenly distributed openings 10 and one opening 11 along the circumference of ring 8, and in the body of carriage 7 there are light sources 12 with opposite photodetectors 13 and 14 arranged so that in rotation of ring 8 a light beam from light sources 12 through openings 10 and 11 falls on photodetectors 13 and 14. Signals of photodetector 13 are used for detecting a rotation angle of ring 8 with sensor 9, and signals of photodetector 14 (when it is first lit through opening 11) are used for registering the moment of starting counting signals of photodetector 13 and controlling carriage 7 motion.

Sensor 9 body is firmly joined to ring 8. A contact element 15 touching the surface of blank 5 and at the same time functionally used for visual indication of special points on blank 5 (the highest and the lowest) is connected to sensor 9 shaft through a lever. A spring 16 presses element 15 against the blank 5 surface, and an electromagnet 17 returns it in the initial position, spring 16 and electromagnet 17 are connected to the lever of contact element 15.

The initial position of contact element 15 is defined (limited) by a fixed stop 18 at a maximum distance from rotation axis O-O of ring 3; the value of this distance R_{max} defines the size of work space for accommodating blanks 5 and serves as reference value for calculating values of radius R characterizing position of points on blank 5 surface in relation to ring 8 axis O-O.

In the claimed structure linear movements of contact element 15 (initiating turn of sensor 9 shaft) are transformed in sensor 9 into corresponding electric signals adjusted for reverse counting. Sensor 9 can be a displacement sensor based on photoelectric, induction or other concept of electric signal generation.

Sensor 9 output is connected through leads 19 on ring 8 and a current collector 20 attached to the carriage 7 to data processing unit 21 providing reverse counting, coding and sending

signals received from sensor 9 to the input of a microprocessor 22. Unit 21 is also connected to photodetectors 13 and 14.

The output of a microprocessor 22 is connected to central heads 2 and carriage 7 through a control unit 23 for controlling work movements of operating devices including movements of centering heads 2.

For manual control of the movements (when the machine is used under conditions of non-automatic production) microprocessor 22 is provided with a display 24 for indicating said positioning and output of data required for the fourth and fifth levels of machine operations. Microprocessor 22 is configured (programmed) for selecting an optimal processing for the next (after centering or before centering if a blank needs to be repaired) treatment of the blank. For example, minimum total cost of further treatment may be chosen as a criterion of optimizing, the total cost including rough machining cost, repairing by weld depositing or leveling and taking into account accompanying transportation cost, etc.

The microprocessor receives data on real geometry of a blank from sensor 9 and unit 21, and data of the finished model from the central server of the automatic system or from any source of information to be used with the machine independent of an automatic system (not shown), and data for calculating parameters of further processing.

For generating commands unit 23 is also connected to photoreceiver 14 sending the signal for carriage 7 to start moving, to end switch 25 sending signal to stop forward movement of carriage 7 and rotation of ring 8.

End switch 25 is connected to microprocessor 22 through unit 23 for generating commands to stop recording data from sensor 9 and start the program saved in microprocessor 22.

For touching blanks with sharp transition from neck to neck the lever connecting contact element 15 with sensor 9 shaft consists of two parts connected to each other by a hinge 26 with spring 27 and end switch 28 connected to control unit 23. Such design allows touching blank surfaces at portions with sharp transition from a small to large neck diameter in the mode of machine operation described below.

For operating at the fourth level, rotating ring 8 is capable of receiving measuring tool units 29 for machining necks of a blank based on support holders of a lathe for further machining the blank. Visual indication of special (the highest and the lowest) points can be provided only with the help of contact elements 15 as described above as well as

automatically.

For automatic visual indication of the special points there are one or more markers mounted on ring 8, for example, spray guns 30 with electric drive connected to the control unit 23. Nozzles 31 of spray guns 30 face blank 5 in radial directions in relation to axis O-O. If there are a few spray guns, they are loaded with paints of different colors. For operating the machine from the third to fifth levels in addition to the output from microprocessor 22 to display 24 it can also be sent to a printing device or a perforator 32 or to a central server of the automatic system.

The machine operates as follows.

At the beginning blank 5 is placed on supports 4 within the working range of contact element 15 (inside an imaginary cylinder of radius R_{max}) and fixed using mounting units 6. Carriage 7 is set in the extreme left position. Contact element 15 is moved by electromagnet 17 to stop 18 at distance R_{max} from ring 8 rotation axis O-O. The data about the geometry of a finished product and data for calculating parameters of further processing are loaded in microprocessor 22.
The machine work process consists of three successive steps: a first step is touching (sizing) the surface of the blank and accumulating data of the blank real geometry; a second step comprises processing obtained data and selecting optimum variant for machining by the microprocessor; a third step comprises realization of the operations calculated at the second step. The process of successive implementation of the steps is described below.

When the machine is switched on, electromagnet 17 is switched off, and contact element 15 is brought in contact with the blank 5 surface by spring 16. At the same time sensor 9 shaft is turned and signals generated by sensor 9 (corresponding to the displacement of contact element 15) pass through leads 19 and current collector 20 to unit 21 where they are processed, and ring 8 starts rotating. Contact element 15 is constantly in contact with the blank 5 surface due to spring 16 pressure, and depending on its geometry contact element 15 turns the shaft of sensor 9. Unit 21 counts received signals reversely so that registered algebraic sum of the figures is equivalent to the turn of sensor 9 relative to its initial position (when contact element 15 was deflected to stop 18).

On a signal from photoreceiver 14 at the moment when for the first time opening 11 and light source 12 coincide, simultaneously carriage 7 starts moving along base 1 to the right being kinematically connected to ring 8 rotation causing contact element 15 to move on the surface of blank 5 along a helical curve. The registration of signals from photoreceiver 13 occurs each time when it aligns with the light beam direction from the second light source 12 through each of the openings 10 in rotating ring 8.

For each signal from the photoreceiver the algebraic sum of sensor 9 signals registered by unit 21 and corresponding to current angle α of sensor 9 shaft turn is sent in encoded form to the input of microprocessor 22 forming an array of data consisting of arranged numbers wherein each number corresponds to an angle of sensor 9 turn, and serial number of each of the numbers corresponds to the position of the point on the blank 5 surface. The position of the first point is defined by the initial positions of photoreceiver 14, opening 11, sensor 9 with contact element 15. Positions of the following points are determined by kinematic relation between the speed of carriage 7 linear motion and the speed of ring 8 rotation, i.e., by the thread pitch and the pitch angle between openings 10 in ring 8.

Touching the blank surface by contact element 15 moving along the helical curve can be continuous. However in case the blank is stepped with steep transition from a smaller to a bigger diameter (about 90°), a side force acts on contact element 15 which is bigger than the force exerted by the spring and turns the contact element 15 lever around hinge 26 switching on switch 28 connected to unit 23. On command of unit 23 electromagnet 17 returns contact element 15 to stop 18; when next signal from photoreceiver 13 (through unit 21) is received by unit 23, carriage 7 and ring 8 are stopped, electromagnet 17 is switched off, and contact element 15 touches the blank 5 surface under the action of spring 16, sensor 9 shaft turns sending signals to unit 21. After this signal is received, the motion of carriage 7 and ring 8 recommences and continues until the side force acts on contact element 15 again causing halts as described above.

Composing the data array and conducting the first step of the work process come to the end after contact element 15 finishes moving along the whole blank 5 (with predetermined discontinuity), and carriage 7 and ring 8 motion halts on the signal from end switch 25. The same signal starts calculation by microprocessor 22 and beginning of the second step of the machine operation.

As the trajectory of contact element 15 relative motion from stop 18 to the blank 5 surface (an ark with the center on the axis of sensor 9 shaft) deviates from the radial direction to a center on axis O-O (Fig. 3), coordinates of special points on the blank 5 surface should be

calculated with correction of $\Delta\varphi$ so that the angle position of any point K is $\varphi_K+\Delta\varphi_K$ where φ_K is a rotation angle of ring 8 determined, indicated above, by serial number of number array saved in the microprocessor 22 memory.

As it is shown in Fig. 3 polar radius R and correction $\Delta\varphi$ are in unique dependence on turn angle α of the sensor 9 shaft, i.e. $R=f(\alpha)$ and $\Delta\varphi = f(\alpha)$ (precise mathematical expressions for the functions have been obtained but not given to make it simpler). Transformation of data saved in microprocessor 22 memory (registered by unit 21 according to signals from sensor 9) is their presentation as polar coordinates of the points on the blank 5 surface, i.e. position of any point K is represented by a pair of numbers R_k *and* $\varphi_K+\Delta\varphi_K$.

Then microprocessor 22 selects an optimum variant of further treatment of the blank. Further machine operations at the second and third steps are described under the assumption that it is possible to repair the blank by weld deposits or leveling. If it is impossible, all operations are not

carried out.

Assuming that the weight of removed allowance is constant, it is possible to consider that labor expenditure (cost) of further rough machining is lower when the allowance is evenly distributed on the surface of an article. For achieving such result it is sufficient to position correspondingly the axis of the processed article inside its volume limited by its real surface.

Using data of the real blank surface geometry and geometry of the finished article, microprocessor 22 makes necessary processing according to the program. The calculation can be based on the method of iterations when a sequence of positioning the axis of finished article is checked, and one of them is selected as corresponding to a minimum labor cost of further machining; the geometrical parameters of such positioning are recorded. Remaining non-uniformity of allowance distribution is characterized, for example, by difference between the biggest and the smallest linear values in the highest and lowest points of the blank surface.

Using the methods mentioned above (weld depositing, leveling or a combination of both), it is possible to decrease remaining irregularity of allowance distribution. As shown in Fig. 6 weld deposit in point A and further shifts of the finished article axis in the direction of arrows B may decrease unevenness of allowance distribution along diameter D. The same result may be achieved by leveling distorted blank at the highest point H (Fig. 7).

Following the program, microprocessor 22 calculates economical practicability of repairing the blank. There may be two variants of the result.

According to the first variant it may happen that the cost of repairing the blank is higher than decrease in labor cost saving due to smaller unevenness in the allowance distribution, i.e. blank repair is not economical.

In such case further operation during the second step performed by microprocessor 22 is calculation of machining the necks (for further processing). The following issues are taken into account.

As well known, machining of large shaft necks is carried out at low cutting mode mainly due to disbalance of the blank in relation to its rotation axis.

It may happen that the machine is capable of machining necks at higher mode though rigidity of such machine is lower that that of a lathe as known to a person skilled in the art. The cost of operation may be lower than for a lathe. In such case microprocessor 22 calculates a number of required cuts, sizes of tool units and other parameters of machining and sends them to the display 24. This is the end of the second step of the operation for a blank that does not require a repair (repair is not economical).

At the third step microprocessor 22 generates a program of further machining the blank on a programmed numerical control lathe and outputs it with the help of a perforator 32 or on any suitable medium, for example on a perforated tape, or sends it to a server of the system. At the same time the values of central head 2 displacements are calculated in relation to earlier fixed position of the finished article axis in the volume of the blank material.

For manual operation these data are displayed. For automatic operation the data are sent to the heads 2 through control unit 23. Blank 5 is centered with work tools 3, then heads 2 return in the initial position when work tools 3 are aligned with the rotation axis O-O of ring 8. Then supports 4 are adjusted so that the centers of blank 5 are aligned (manually or automatically on commands from microprocessor 22 and unit 23 without removing mounting units 6) with the rotation axis O-O of ring 8. Tool units 29 are mounted on ring 8. Ring 8 rotates and carriage 7 starts moving machining shaft necks under manual or automatic control according to the data generated by microprocessor 22 (at the second step).

This ends the third (and the last) step of the machine work operation; blank 5 is removed and transferred together with the program to a lathe for further machining. However a second variant may be obtained from the calculation of economical advisability of blank repairing, when the cost of blank 5 repair is less than the gain due to less labor cost of

machining (as a result of more even distribution of allowance). In such case as well as in all cases when it is not possible to produce finished article because of insufficient allowance corresponding information appears on display 24, and the second step of machine work ends.

In such case at the third step microprocessor 22 calculates the values of required repairs and shows the result on display 24 and through control unit 23 moves carriage 7 with ring 8 for visual indication of blank 5 special places (the lowest and the highest) that require repair stopping carriage 7 and ring 8 and releasing contact element 15 to the blank 5 surface. These places are marked manually.

Automatic visual indication of the points is made by spray guns 30 switched on by unit 23. Paint is sprayed on the blank surface at each of the special points. If a few spray guns are loaded with paints of different colors, different points that require different repairs can be marked with different colors.

After repairs the machine operation repeats through all three steps as described above.

Claims

1. A centering machine for centering forged blanks of large shafts comprising adjustable supports mounted on a machine base and centering heads with work tools, *characterised in that* for widen machine technological capabilities it is equipped with an additional sliding carriage with rotatable device having attached sensor with a sensitive element used for interaction with the blank and arranged to be rotatable around the blank and moving along its generating line, wherein the sensitive element is in the form of a lever with a drive for moving the lever to the blank and returning to a fixed stop mounted on the rotatable device; the centering heads and the carriage can be positioned and linked to a microprocessor control system.

2. The centering machine according to claim 1, *characterized in that* the lever consists of two hinged spring-loaded parts; one part is connected to a machine end switch with a probe contacting the surface of the second lever part.

3. The centering machine according to claim 1, *characterized in that* at least one marker comprising a spray gun with electric drive connected to the system of microprocessor control is attached to the rotatable device for automatic visual indication of defective points on the blank.

4. The centering machine according to claim 1, *characterized in that* measuring cutter blocks are attached to the rotatable device for saving on labor cost for further machining the blank.